A STATISTICAL STUDY OF THE METAPODIALS OF THE DIRE WOLF from the PLEISTOCENE OF RANCHO LA BREA

by

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It is a pleasure to acknowledge the help of Dr. Chester Stock who originally suggested the problem and who has guided and assisted its investigation in several ways.

Introduction

Although many features of the Rancho La Brea Pleistocene asphalt deposits are well known to every student of paleontology, much material has remained virtually untouched or has received very little study since the time of the excavation. This is unfortunate, since the large numbers of individuals of certain forms offer opportunities for faunal studies rarely found when dealing with fossil collections. A striking example is furnished by the remains of dire wolves representing more than a thousand individuals.

The dominant canine species from Rancho La Brea is Aenocyon dirus, but smaller forms are also identified, namely the coyote (Canis orcutti) and the timber wolf (Canis furlongi). The latter animal is represented by eight skulls. Little work has been done on the osseous elements other than skulls. The present paper presents the results of a study of the fossil foot bones or metapodials in the Los Angeles County Museum collection that were originally segregated and identified as belonging to Aenocyon dirus.

This study was undertaken in an attempt to identify skeletal elements of both the timber wolf and dire wolf by a statistical evaluation of all the large canid metapodials available. Whether or not a satisfactory solution of

the problem has been reached, the accumulated data have significance in other ways. Since the number of timber wolves, as established by a ready identification of their skulls from the Pleistocene asphalt, is neglible in comparison to the overwhelming number of dire wolves, it is possible to subject the material and data to statistical analyses in order to determine the arithmetic mean and standard deviation in size of the fossil metapodials, and the standard errors of these quantities. It is likewise possible to arrive at a rather accurate estimate of the average sizes of the eight kinds of metapodials (metacarpals and metatarsals II, III, IV, V) of Aenocyon dirus from Rancho La Brea. These results are presented in what follows in a series of bar graphs and histograms. Lastly, information is presented for what it is worth suggestive of differences in geologic age among the collections of metapodials derived from the several excavations at Rancho La Brea.

Certain positive and negative features met with in the present investigation should receive comment. Thus, the amount of material utilized is far greater than that usually available to a paleontologist engaged in statistical studies. It is assumed that only a single species* of dire wolf is present in the Pleistocene asphalt. Furthermore, the sample of bones

treated in the present statistical analysis is by no means pure. It cannot be asserted, for example, that only fully adult individuals are represented, although the obviously immature bones have been excluded from the sample. Both sexes are likewise represented by the material. Lastly, as suggested above, it is by no means certain that all the metapodials come from exactly the same stage in Pleistocene time.

* Merriam described not only Canis dirus but also Canis milleri from Rancho La Brea. The latter species is now regarded as not valid and has become synonymous with dirus.

Procedure

For the purpose of this study, measurements of the metapodials were confined only to the longitudinal dimensions. Care was taken to obtain uniform orientation for each reading. While transverse measurements are unquestionably desirable, the difficulties attendant upon orientation to obtain this dimension and the limited time available made it impracticable to measure girth or thickness. Special calipers with verniers were used. Readings were made to the nearest tenth of a millimeter.

No attempt was made to reduce the total number of metapodials to representative samples. It seemed desirable to utilize as many specimens as were available, since the unusually large number of each metapodial afforded an unprecedented opportunity to obtain the desired statistical data.

An average of 1300 individual elements for each metacarpal and metatarsal, both right and left, were measured and studied. Metacarpal I, because of its greatly diminished size and distinctly less frequent occurrence, was omitted. Thus, in all more than 20,000 bones of wolves from Rancho La Brea were measured.

Table 1

Means and Standard Deviations of Metapodials of Aenocyon dirus

Metapodial	N*	Mean	±	Standard Deviation	±
MC II R	1163	77.04	.09	3.124	.065
" L	1219	77.23	.09	3.292	.067
MC III R	1261	88.05	.10	3.644	.071
"	1239	88.05	.10	3.622	.073
MC IV R	1177	87.21	.11	3.614	.074
" L	1266	86.95	.10	3.493	.067
MC V R	1298	73.86	.09	3.216	.063
" L	1268	73.84	.09	3.290	.066
MT II R	1251	83.40	.10	3.411	.068
" L	1265	83.33	.10	3.444	.069
MT III R	1283	94.05	.11	3.784	.075
" L	1249	93.96	.11	3.850	.077
MT IV R	1239	96.33	.11	3.928	.079
" L	1220	96.17	.11	3.796	.077
MT V R	1088	88.08	.11	3.511	.075
" L	1136	88.08	.10	3.496	.073

* Number

Table 2

FREQUENCY DISTRIBUTION METACARPAL II - Left

Cm. Size	Total	Los Angeles County Museum Excavation Nos.																		
		0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36	10
6.5	1		1																	
6.6	0																			
6.7	3			1	1							1								
6.8	1		1																	
6.9	4		2		1		1													
7.0	14		7	1	1	1	3					1								
7.1	16		9		6							1								
7.2	41	1	15	7	9	2	1			1	2	3								
7.3	62	2	27	6	10		7				3	5			2					
7.4	86	1	38	7	18	5	9				1	5			1	1				
7.5	144	1	57	11	17	17	21			3	2	12	3							
7.6	128	5	42	13	18	14	15			4	2	15								
7.7	159	4	60	26	16	14	18			4	1	12	4							
7.8	146	3	58	27	14	8	17				5	11	2			1				
7.9	122	1	50	22	7	14	11			2		14	1							
8.0	125	3	37	26	8	15	21			2	2	2	3							
8.1	60		19	16	6	3	7			2	1	4	1			1				
8.2	41		6	15	1	4	9					5	1							
8.3	25		6	6	2	1	4			2	1	3								
8.4	22		5	4	2	2	4	1			1	3								
8.5	10		4	3	1		1					1								
8.6	5	1				1	2			1										
8.7	2				1		1													
8.8	1				1															
8.9	1				1															
9.0	0																			
9.1	0																			
9.2	0																			
	1219																			

Table 3

FREQUENCY DISTRIBUTION METACARPAL II - Right

Cm. Size	Total	Los Angeles County Museum Excavation Nos.																	
		0.3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36	10
6.5	0																		
6.6	0																		
6.7	1		1																
6.8	1	1																	
6.9	9	2 2	2	2		1													
7.0	11	3	1	3	1	1					2								
7.1	21	9	2	4	2	2					2								
7.2	28	1 8	5	4	2	3				1	3	1							
7.3	59	3 24	5	8	6	6			1	1	3	1	1						
7.4	105	2 39	13	23	8	11					7	2							
7.5	132	7 42	11	22	16	14			2	3	10	1	3		1				
7.6	137	5 52	18	18	12	15			1	4	8	3		1					
7.7	140	4 44	23	13	16	18			5	3	11	1	2						
7.8	156	4 59	28	16	14	18			4	1	10	1	1						
7.9	124	2 44	32	7	4	11		1	1	7	12	2	1						
8.0	104	32	30	5	8	13		1	3	1	10	1							
8.1	60	2 13	17	3	6	7			4	4	3	1							
8.2	37	1 12	11	2	3	3			1		3	1							
8.3	19	4	3	1	5	1		1	1	2	1								
8.4	9	1 1	3		2	1	1												
8.5	4	2	2																
8.6	4	1	1		1	1													
8.7	0																		
8.8	1			1															
8.9	0																		
9.0	0																		
9.1	0																		
9.2	1	1																	
	1163																		

Table 4

FREQUENCY DISTRIBUTION METACARPAL III - Left

Cm. Size	Total	Los Angeles County Museum Excavation Nos.																
		0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37
7.6	2	1			1													
7.7	0																	
7.8	3		1		1							1						
7.9	5	1	2		1	1												
8.0	5		2		1	1												
8.1	20	1	9	1	7		2											
8.2	22		5	2	9	1	4					1						
8.3	61		30	8	11	1	5					5						
8.4	71	5	23	7	13	7	6			1	2	7						
8.5	122	5	48	15	15	9	17			2	1	8		1				1
8.6	137	1	55	10	18	14	20			5		12	2					
8.7	103	4	35	11	22	7	13			2	3	4	2					
8.8	136	2	49	18	14	12	19			6	4	9	2				1	
8.9	129	1	46	31	13	10	12			2	2	9	2			1		
9.0	119	1	43	18	6	11	18			3	2	13	4					
9.1	97	2	32	21	3	11	17			1		7	2	1				
9.2	78	1	23	18	6	4	13					11	1	1				
9.3	51	2	14	18	1	7	4			1	1	2	1					
9.4	30	1	6	10	1	3	7		1	1								
9.5	18		10	6		1						1						
9.6	16		2	6		3				1		4						
9.7	7			2		1						2	2					
9.8	6			1	1	2						1	1					
9.9	0																	
10.0	1											1						
10.1	0																	
10.2	0																	
10.3	0																	
10.4	0																	
10.5	0																	
	1241																	

Table 5

FREQUENCY DISTRIBUTION METACARPAL III - Right

Cm. Size	Total	Los Angeles County Museum Excavation Nos. 0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90
7.0	0																
7.1	0																
7.2	0																
7.3	1		1														
7.4	0																
7.5	1											1					
7.6	0																
7.7	1		1														
7.8	1		1														
7.9	4	1	2		1												
8.0	14		6		5	2						1					
8.1	19		10		4	1	4										
8.2	29	1	9		7	3	6					3					
8.3	51	1	20	3	12	3	6			1		4					1
8.4	66	4	31	7	8	10	2				1	3					
8.5	124	2	49	13	24	11	15					10					
8.6	106	4	40	10	11	14	15		2		3	5	2				
8.7	132	5	52	16	15	8	9		5	2	2	15	2	1			
8.8	143		58	25	15	7	18			3	3	8	4	1			1
8.9	133	4	49	16	16	14	10			5	1	13	3	1			1
9.0	129	3	53	29	8	14	13					6	1	1		1	
9.1	110	4	34	22	9	6	12			5	4	9	4	1			
9.2	71	2	22	20	3	10	4				2	6	2				
9.3	52		22	12	2	6	4				1	4	1				
9.4	29		10	11			2			1	2	3					
9.5	17		5	5		3	3					1					
9.6	12		3	5			1					3					
9.7	8		1	2		2	2			1							
9.8	5		3	1									1				
9.9	0																
10.0	0																
10.1	1		1														
10.2	1					1											
10.3	0																
10.4	0																
10.5	1			1													

Table 6

FREQUENCY DISTRIBUTION METACARPAL IV - Left

Cm. Size	Total	Los Angeles County Museum Excavation Nos.																	
		0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	10
7.6	1				1														
7.7	2				1							1							
7.8	3		1		1											1			
7.9	10		4	1	2	1	1												1
8.0	22		11		3	3	1			1	1	1			1				
8.1	22	1	11	3	5	1						1							
8.2	61		21	8	13	7	3				1	8							
8.3	85	4	38	8	16	4	8			1		2	3	1					
8.4	85	5	27	7	14	6	13			1		10	2						
8.5	154	5	60	15	28	15	18			1	5	6	1						
8.6	120	5	50	9	13	11	14			2	3	9	4						
8.7	120		37	24	14	10	19			2	2	9	1			1	1		
8.8	127		48	25	10	6	16			4	3	14					1		
8.9	126	3	46	27	10	11	13			4	2	9	1						
9.0	97	2	21	25	7	14	12			3	1	10	1						1
9.1	86	2	19	21	7	6	20			1	1	7	2						
9.2	68		20	24	3		10			1	2	6	2						
9.3	30	1	9	7	2	3	5		1				2						
9.4	20	1	7	3		1	4			2	1	1							
9.5	17		3	6		2	3			1		2							
9.6	5		1	1		2							1						
9.7	4		3				1												
9.8	1												1						
9.9	0																		
10.0	0																		
	1266																		

Table 7

IV

FREQUENCY DISTRIBUTION METACARPAL - Right

Cm. Size	Total	Los Angeles County Museum Excavation Nos.																	
		0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36
7.5	1				1														
7.6	0																		
7.7	1						1												
7.8	7	1	2		3							1							
7.9	7	1	1	1	2	1							1						
8.0	20		8	2	5	1	3							1					
8.1	20	1	9	4	3	2	1												
8.2	49	2	20	3	8	5	5			1		4					1		
8.3	67	3	28	7	12	7	4			1	3	2							
8.4	71	1	27	7	11	9	4					8	4						
8.5	137	2	48	15	19	14	20			1	3	12	1	2					
8.6	130	3	53	20	13	16	17			2	1	4	1						
8.7	125	5	50	16	13	11	6			4	3	12	3	1			1		
8.8	130	1	40	26	17	7	20			2	5	8	4						
8.9	108	2	35	34	4	5	14			2	2	8	1			1			
9.0	95	1	31	21	9	10	10			1	2	7	1	1					1
9.1	75	2	19	20	5	6	9		1	2	3	5	3						
9.2	59		11	19	8	3	11			1	2	3							
9.3	35	1	10	11		4	4			1	2	2							
9.4	9	1	3	1		2	1					1							
9.5	11		1	3	1	1	2			1		2							
9.6	14	1	4	3		2	2			1		1							
9.7	3		1			2													
9.8	1			1															
9.9	0																		
10.0	1	1																	
10.1	0																		
10.2	0																		
10.3	0																		
10.4	1		1																
	1177																		

Table 8

FREQUENCY DISTRIBUTION METACARPAL V - Left

Cm. Size	Total	Los Angeles County Museum Excavation Nos. 0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36
6.2	2		1			1													
6.3	2				2														
6.4	2				1							1							
6.5	1				1														
6.6	8		4		2	1						1							
6.7	8		2	1	2	2	1												
6.8	23	2	16	1		1	2					1							
6.9	41	3	11	8	8	4	4				1	2							
7.0	100	5	29	17	22	7	7			1	1	8	2		1				
7.1	125	2	54	8	28	8	10			3	1	10	1						
7.2	154	8	63	13	19	11	12			2	3	21	1	1					
7.3	128	4	35	17	18	12	19			3	3	15	2						
7.4	160	5	57	28	12	9	16			2	3	24	2	1					1
7.5	146	2	46	27	10	10	14			4	4	23	3	1			2		
7.6	112	1	38	22	7	12	10			1	5	10	6						
7.7	100	1	32	22	9	12	7			1	1	11	3		1				
7.8	52		16	14		3	6			2	3	6	1		1				
7.9	40		8	14	3	3	5			1	1	1	2	1		1			
8.0	34	1	8	8			7			1	2	5	2						
8.1	12		3	6						1	1	1							
8.2	9		1	3		3	2												
8.3	5		2	1						1			1						
8.4	2		1		1														
8.5	1				1														
8.6	0																		
8.7	1				1														
8.8	0																		
8.9	0																		
	1268																		

Table 9

FREQUENCY DISTRIBUTION METACARPAL V - Right

Cm. Size	Total	Los Angeles County Museum Excavation Nos.																	
		0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36
6.3	3		2			1													
6.4	1											1							
6.5	2		1		1														
6.6	6	2	2		1		1												
6.7	12	1	7	1	1	1	1												
6.8	31	1	15	2	7	1	3					2							
6.9	54	3	20	4	8	5	5					9							
7.0	66	3	20	5	17	4	6					8	2				1		
7.1	113	3	47	7	20	9	13	1		1	3	9							
7.2	149	4	60	14	22	13	13			4	4	13	1			1			
7.3	150	8	50	23	17	24	12			4	2	8	1			1			
7.4	174	9	64	28	19	8	17		1	5	3	14	4				1		1
7.5	156	4	51	38	10	14	16			6	1	11	2	2	1				
7.6	118	3	41	28	6	11	14			1	4	7	2	1					
7.7	104	1	36	27	6	8	11			1		13	1						
7.8	81	2	20	17	4	10	8			2	3	10	2	1	2				
7.9	31	2	5	6	3	3	3			1		6	2						
8.0	15		4	3	1	1	2			1	1	1	1						
8.1	20	3	5	5	3	1				1	1	1							
8.2	7		3	2			2												
8.3	3		1			1							1						
8.4	0																		
8.5	0																		
8.6	1											1							
8.7	0																		
8.8	0																		
8.9	1		1																
	1298																		

Table 10

FREQUENCY DISTRIBUTION METATARSAL II - Left

Cm. Size	Total	Los Angeles County Museum Excavation Nos. 0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36	10
7.1	1		1																	
7.2	0																			
7.3	1	1																		
7.4	4	1		1	1							1								
7.5	6		2		1	1	1					1								
7.6	11	1	7		3															
7.7	27		11	4	6	1						1	2				2			
7.8	43	4	16	1	12	2	3			1		2	2							
7.9	52	2	22	5	7	4	5			1		3		1		1	1			
8.0	111	6	39	8	24	7	13					12	1				1			
8.1	117	4	38	22	17	12	8			2	1	11	2							
8.2	164	3	58	25	23	16	14			3		15	6	1						
8.3	143	2	41	21	16	22	21			3	2	11	4							
8.4	139	4	43	26	14	9	22			2	1	13	4	1						
8.5	142	1	49	29	12	17	22			1	1	9	1							
8.6	87	1	20	25	3	10	14			2	1	11								
8.7	73		22	17	4	8	10			1	3	7	1							
8.8	54		11	17		10	10			1		5								
8.9	36		12	6	3	1	9					5								
9.0	30		6	9	3	4	1					7								
9.1	11		2	2	2	2	2				1									
9.2	7		3	1			2					1								
9.3	0																			
9.4	1		1																	
9.5	3				1	1	1													
9.6	1		1																	
9.7	1				1															
9.8	0																			
9.9	0																			
10.0	0																			
	1265																			

FREQUENCY DISTRIBUTION METATARSAL II - Right

Cm. Size	Total	Los Angeles County Museum Excavation Nos.																			
		0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36	10	6
7.1	0																				
7.2	2		1		1																
7.3	0																				
7.4	1				1																
7.5	5		1	1	2	1															
7.6	10		3		2		3				1									1	
7.7	20		7	1	6	2	2				1	1									
7.8	45	1	19	2	10		4				1	7	1								
7.9	67	3	26	2	15	10	6				1	3					1				
8.0	109	4	33	13	26	9	9			3		10	2								
8.1	107	5	37	13	19	14	10				2	5	1	1							
8.2	160	3	62	17	22	20	13			3	1	14	4	1							
8.3	130	3	48	22	12	11	10			5	4	12	1			1					1
8.4	110	3	40	20	14	11	12			1	1	7	1								
8.5	166	9	63	27	10	14	19			6	3	10	3	1	1						
8.6	96	1	31	22	3	9	15			3	1	6	4		1						
8.7	80		27	14	1	11	14			1	2	9	1								
8.8	66	2	20	13	6	4	12					6	3								
8.9	29		3	13	1	4	5				1	2									
9.0	24	1	5	5	3	1	5			1	1	1	1								
9.1	15	3	4	4	1		1			1		1									
9.2	2		1			1															
9.3	2		1	1																	
9.4	1		1																		
9.5	1		1																		
9.6	0																				
9.7	2				2																
9.8	0																				
9.9	0																				
10.0	1		1																		
	1251																				

Table 11

Table 12

FREQUENCY DISTRIBUTION METATARSAL III - Left

Cm. Size	Total	Los Angeles County Museum Excavation Nos.																			
		0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36	10
8.1	2		1	1																
8.2	0																			
8.3	0																			
8.4	4				2		1					1								
8.5	8	1	3	3		1														
8.6	17	1	6	2	5	1						1					1			
8.7	18		7	2	6	1					1		1							
8.8	34	2	13	1	8	4	2					4								
8.9	57	1	26	5	8	3	7				1	5	1							
9.0	83	2	29	9	13	11	7				2	7	2	1						
9.1	91	9	33	16	12	8	8					4					1			
9.2	123	3	37	19	21	6	18			1	4	12	1			1				
9.3	127	2	50	14	15	8	17			6		12	3							
9.4	147	4	51	20	14	20	20				5	9	3						1	
9.5	136	4	34	24	16	9	29			2	2	9	5	1	1					
9.6	109	3	37	27	10	8	14			2		5	3							
9.7	84	1	27	22	7	5	12			1	1	4	1	2	1					
9.8	57	2	16	18	1	5	11			2		2								
9.9	58	1	18	17	2	8	4	1		1		5	1							
10.0	38	1	8	11	2	3	9			1		3								
10.1	28	1	9	9	1		4			2		2								
10.2	12		4	5	1	1	1													
10.3	9		3	3	1	1	1													
10.4	3	1	1										1							
10.5	2		1		1															
11.3	2		2																	
	1249																			

Table 13

FREQUENCY DISTRIBUTION METATARSAL III - Right

Cm. Size	Total	Los Angeles County Museum Excavation Nos. 0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36	10
8.1	0																			
8.2	4		1		2							1								
8.3	0																			
8.4	3				2							1								
8.5	2		2																	
8.6	11		5	2	2	1	1													
8.7	21	1	7	1	8		4													
8.8	40	5	16	2	8		6				1	2								
8.9	63	4	25	4	14	5	5			1		4		1						
9.0	73	2	33	7	8	5	10				1	5	1	1						
9.1	116	3	54	9	20	12	11					4	1	2						
9.2	117	3	50	7	19	9	16			1	1	7	3		1					
9.3	126	4	52	12	11	12	18			3	3	7	2	2						
9.4	135	2	51	18	15	9	15			3	6	13	1	1		1				
9.5	153	3	64	13	23	13	19			2	3	11		1	1					
9.6	94	2	35	21	8	7	12			2	2	4				1				
9.7	105	1	27	27	9	12	16			4	1	5	3							
9.8	66	4	17	20	7	12				2		3	1							
9.9	56		21	17		2	8					6	2							
10.0	38	1	11	8	4	2	7			1	1	2	1							
10.1	28		7	8	1	4	4			1		3								
10.2	14	1	1	9		1	2													
10.3	11		2	6			1					2								
10.4	5			2		1						1	1							
10.5	0																			
10.6	0																			
10.7	2	1			1															
	1273																			

Table 14

FREQUENCY DISTRIBUTION METATARSAL IV - Left

Cm. Size	Total	Los Angeles County Museum Excavation Nos. 0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36	10
8.3	1		1																	
8.4	0																			
8.5	0																			
8.6	2				1		1													
8.7	5		4		1															
8.8	9	1	2		2	1	2					1								
8.9	24	1	10	2	4	1	1					3		1			1			
9.0	41	7	12	2	6	4	4				1	5								
9.1	53	1	22	6	11	1	5			1		3	2			1				
9.2	70	2	33	3	13	4	9					5	1							
9.3	88	3	31	11	14	8	12			1		6		1	1					
9.4	107	7	39	9	20	10	9			4	2	7								
9.5	129	5	45	24	10	14	14			2	2	10	2			1				
9.6	138	2	43	27	14	16	13	1		5	3	10	2	1	1					
9.7	114		38	18	11	16	13			1	4	10	2	1						
9.8	112	1	37	26	9	5	19			1	1	12	1							
9.9	86	2	27	18	4	10	9			2	1	9	3		1					
10.0	82		27	16	4	7	16			1		8	3							
10.1	58	2	13	17		9	7				2	5	2		1					
10.2	45		15	18	3	2	5			1		1								
10.3	22	1	5	9	2	1	2			1		1								
10.4	15		5	5		1	2			1		1								
10.5	8			3	2	1	1					1								
10.6	8		2	1	1	1	2						1							
10.7	1												1							
10.8	0																			
10.9	1		1																	
11.5	1		1																	
	1220																			

Table 15

FREQUENCY DISTRIBUTION METATARSAL IV - Right

Cm. Size	Total	Los Angeles County Museum Excavation Nos.																		
		0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36	10
8.3	1		1																	
8.4	1				1															
8.5	1											1								
8.6	3				3															
8.7	5	1	1	2	1															
8.8	14		6	1	2		2					1	1				1			
8.9	21	2	6	3	9							1								
9.0	39	4	14	4	7	2	5				1	1		1						
9.1	43	1	17	1	11	3	5			1	1	2		1						
9.2	72		36	5	15	3	5				3	3	2							
9.3	92	1	35	10	18	9	9				1	9								
9.4	99	3	42	12	17	7	12			1	1	2		2						
9.5	132	1	47	18	21	14	22			2		4	3							
9.6	114	2	49	17	10	15	12					8	1							
9.7	124	3	45	20	13	11	18			1	1	9	3							
9.8	139	3	50	24	14	12	17			5	2	8	3	1						
9.9	85	2	26	27	4	10	4	1	1	2		6	2							
10.0	75		21	18	6	7	16			1		3	3							
10.1	60	2	18	15	2	5	9			1		6				1	1			
10.2	40		10	11	4	5	6				1	1	1			1				
10.3	31		10	7	1	4	3			2		1	3							
10.4	27	2	3	6	3	4	4			1	1	3								
10.5	14			7		5					1			1						
10.6	4		1	1	1					1										
10.7	0																			
10.8	1		1																	
10.9	0																			
11.0	1				1															
11.1	0																			
11.2	1				1															
	1239																			

Table 16

FREQUENCY DISTRIBUTION METATARSAL V - Left

Cm. Size	Total	Los Angeles County Museum Excavation Nos. 0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36	10
7.5	1		1																	
7.6	1			1																
7.7	0																			
7.8	0																			
7.9	1	1																		
8.0	5	2	2			1														
8.1	18		9	1	1	2	1				2	2								
8.2	30		13	3	5	2	4			1		1					1			
8.3	53	2	28	5	5	4	5			1		3								
8.4	64		22	7	19	6	6					2	1		1					
8.5	79	1	25	6	20	8	8			2		8	1							
8.6	110	4	37	10	23	8	14			2	2	9	1							
8.7	139	5	52	23	16	13	15			4	1	6	3						1	
8.8	125	3	40	20	13	14	17	1			4	10	2	1						
8.9	125	2	46	22	14	10	15			3	1	9	3							
9.0	125	1	39	28	9	16	17			2	3	8	1				1			
9.1	79	1	27	19	4	6	13		1		2	4	2							
9.2	69	2	17	18	6	6	12			1	2	3	1	1						
9.3	53		22	10	3	3	9			1	1	4								
9.4	22		3	8		1	6				1	1	2							
9.5	19		3	9	1		5					1								
9.6	6		1	1	2	2														
9.7	5		2	1			1						1							
9.8	3				1		1			1										
9.9	2			1	1															
10.0	1	1																		
10.6	1		1																	
	1134																			

Table 17

FREQUENCY DISTRIBUTION METATARSAL V - Right

Cm. Size	Total	Los Angeles County Museum Excavation Nos. 0	3	4	13	61	67	20	57	16	60	77	2	91	9	1	90	37	36	10
7.8	2				1							1								
7.9	2		1	1																
8.0	12		4	2	5							1								
8.1	13	1	6	1	2		1				1	1								
8.2	25	3	11	1	5	2						3								
8.3	46	1	18	4	7	4	7					5								
8.4	57	1	18	10	15	4	5				1	2	1							
8.5	104	2	40	13	21	10	8			1	1	7					1			
8.6	98	2	43	17	10	9	10				1	3	1	1		1				
8.7	118	3	39	20	13	9	16			3	3	10	2							
8.8	127	4	48	15	8	15	18			1	4	11	3							
8.9	99	3	38	12	11	7	13			2	1	11	1							
9.0	123	7	43	16	6	16	16			2	3	9	4			1				
9.1	89	1	29	23	4	8	12			2		7	3							
9.2	73	1	22	18	2	13	9			1	1	4	2							
9.3	37	2	10	9	1	4	5			1		4					1			
9.4	31	1	13	6	2	1	5					1	2							
9.5	16		4	7			3			1		1								
9.6	6		2	2		1	1													
9.7	6			2			3						1							
9.8	2			2																
9.9	0																			
10.0	1			1																
10.1	0																			
10.2	1											1								
	1088																			

Discussion of Statistical Results

Although the largest specimens in the several series of metacarpals and metatarsals lie outside the expected limits of variation in length from the mean of the particular series measured, there is as yet no definite proof that they represent the timber wolf. It seems likely, however, that the largest metapodials, as well as a few of the longer bones within the normal distribution of measurements represent forms differing from Aenocyon dirus. A graphical representation of the frequency distribution of the measurements of length of the dire wolf metapodials (see graph, figure 1) certainly suggests this, and it seems to be confirmed by the calculated standard deviation.

It is interesting to note that according to Merriam (1912, p. 239) "The metatarsals like the metacarpals, are relatively somewhat shorter in the average specimen of C. dirus than in C. pambasileus, though large specimens are present which exceed the largest measurements known in the latter form." It is not now known how many specimens of the modern timber wolf were actually used by Merriam as a basis for this statement, but the assumption is that the number was not great.

Average size of metapodials. - Figure 1 gives graphically and numerically the average sizes of metacarpals and metatarsals of Aenocyon dirus, based upon approximately 1300 individuals of each element. It will be noted that each particular metapodial in the manus is shorter than the comparable element in the pes. The third metapodial is longer than the fourth, and the second is longer than the fifth, in the manus; the reverse conditions prevail in the pes. The only element in the series not measured is metacarpal I.

Frequency polygons. - Curves showing the frequency distribution of the measurement of length of the metacarpals and metatarsals of the dire wolf are shown in figures 2 to 9. In analyzing these data the statistical formulae indicated by Simpson and Roe (1939) were utilized. Thus to obtain the standard deviation of the measurement in length for each metapodial the following equation was employed:

$$\sigma = \sqrt{\frac{\Sigma(d^2)}{N}}$$

Writing this without the use of mathematical symbols the equation can be expressed as follows: The standard deviation is equal to the square root of the sum of the squares of the individual variations from the mean divided by the number of observations. The standard deviations are given in table 1.

In connection with this calculation it was desirable to ascertain also the Standard Error of the Standard Deviation. This was derived from the following equation:

$$S.E._{\sigma} = \frac{\sigma}{\sqrt{2N}}, \text{ or } .7071 \times S.E._{M}$$

It was also desirable to ascertain the Standard Error of the Mean. This was derived from the following equation:

$$S.E._{M} = \frac{\sigma}{\sqrt{N}}$$

These quantities have been determined for the metacarpals and metatarsals of the dire wolf and are given in table 18.

Analysis of data with regard to relative age of individual Museum excavations. - An inspection of the pit count and measurement data has given rise to interesting suggestions as to the relative ages of some of the excavations made by the Los Angeles County Museum at Rancho La Brea. Almost without exception the larger metapodials of the dire wolf occur in Pit 4, whereas smaller metapodials seem to be concentrated in Pit 13. The cross-over point in size falls invariably on or very close to the calculated and graphical mean of the curve showing size distribution. The average lengths of the metapodials from Pit 3 were likewise less than

those of the elements from Pit 4, although these differences were not so well marked as in the series from Pit 13. In this connection it is interesting to note that the largest number of metapodials recorded from the individual excavations at Rancho La Brea occurred in Pit 3. An inspection of the histograms (figures 10 and 11) shows the decrease in average sizes of the metapodials extends from Pit 4 to Pit 3 to Pit 13, with Pits 77 and 61-67 occupying intervening positions.

In connection with these statistical data it appears of significance that Howard and Miller (1939, p. 45) and De May (1945, p. 74) call attention to the occurrence of a larger percentage of extinct species of individuals in Pit 4 than in Pit 3. These investigators also note that while a larger percentage of condors and eagles occur in Pit 4 than in Pit 3, there is a larger percentage of hawks, owls, and falcons in Pit 3 than in Pit 4. In other words, a conclusion is reached that the assemblage from Pit 4 is older than that from Pit 3 as indicated by the presence of a greater number of extinct forms, larger number of large raptors and by a smaller number of the smaller raptors in Pit 4 than in Pit 3. These observations would seem to support the conclusion by a review of the statistical data on dire wolf metapodials.

AVERAGE SIZES OF DIRE WOLF METAPODIALS

Pits in Order of Greatest Yield

Metapodial		Pit 3 Aver. Length	Pit 3 Total Spec.	Pits 61-67 Aver. Length	Pits 61-67 Total Spec.	Pit 4 Aver. Length	Pit 4 Total Spec.	Pit 13 Aver. Length	Pit 13 Total Spec.	Pit 77 Aver. Length	Pit 77 Total Spec.	Age Sequence of Pits on Basis of Size Data
MC II	L	7.7	444	7.5	253	7.8	191	7.5	106	7.6	98	
	Mean	77.5		76.0		78.5		74.5		76.5		4,3,77,61-67,13
	R	7.8	393	7.7	232	7.9	131	7.4	132	7.7	75	
MC III	L	8.6	435	8.6	263	8.9	203	8.7	144	9.0	116	
	Mean	87.0		86.0		89.5		86.0		89.0		4,77,3,61-67,13
	R	8.8	483	8.6	241	9.0	198	8.5	140	8.8	95	
MC IV	L	8.5	437	8.5	262	8.9	214	8.5	150	8.8	96	
	Mean	85.5		85.0		88.5		85.0		87.5		4,77,3,61-67,13
	R	8.6	402	8.5	242	8.8	214	8.5	134	8.7	80	
MC V	L	7.2	427	7.3	221	7.4	210	7.1	131	7.4	140	
	Mean	73.0		73.0		74.5		71.5		74.0		4,77,3,61-67,13
	R	7.4	455	7.3	242	7.5	182	7.2	146	7.4	115	
MT II	L	8.2	405	8.3	285	8.5	219	8.0	153	8.2	113	
	Mean	82.0		82.5		85.0		80.0		82.0		4,61-67,77,3,13
	R	8.2	435	8.2	262	8.5	190	8.0	157	8.2	94	
MT III	L	9.4	416	9.4	268	9.6	228	9.2	146	9.3	85	
	Mean	94.5		94.5		96.5		92.0		93.5		4,3,61-67,77,13
	R	9.5	481	9.5	262	9.7	193	9.2	162	9.4	81	
MT IV	L	9.5	413	9.6	258	9.8	215	9.4	132	9.8	98	
	Mean	95.5		95.5		98.5		94.5		97.5		4,77,3,61-67,13
	R	9.6	439	9.5	264	9.9	209	9.5	165	9.7	69	
MT V	L	8.7	390	9.0	251	9.0	195	8.6	143	8.8	62	
	Mean	87.5		89.0		90.5		85.5		88.0		4,61-67,77,3,13
	R	8.8	389	8.8	235	9.1	182	8.5	113	8.8	82	

Figure 10

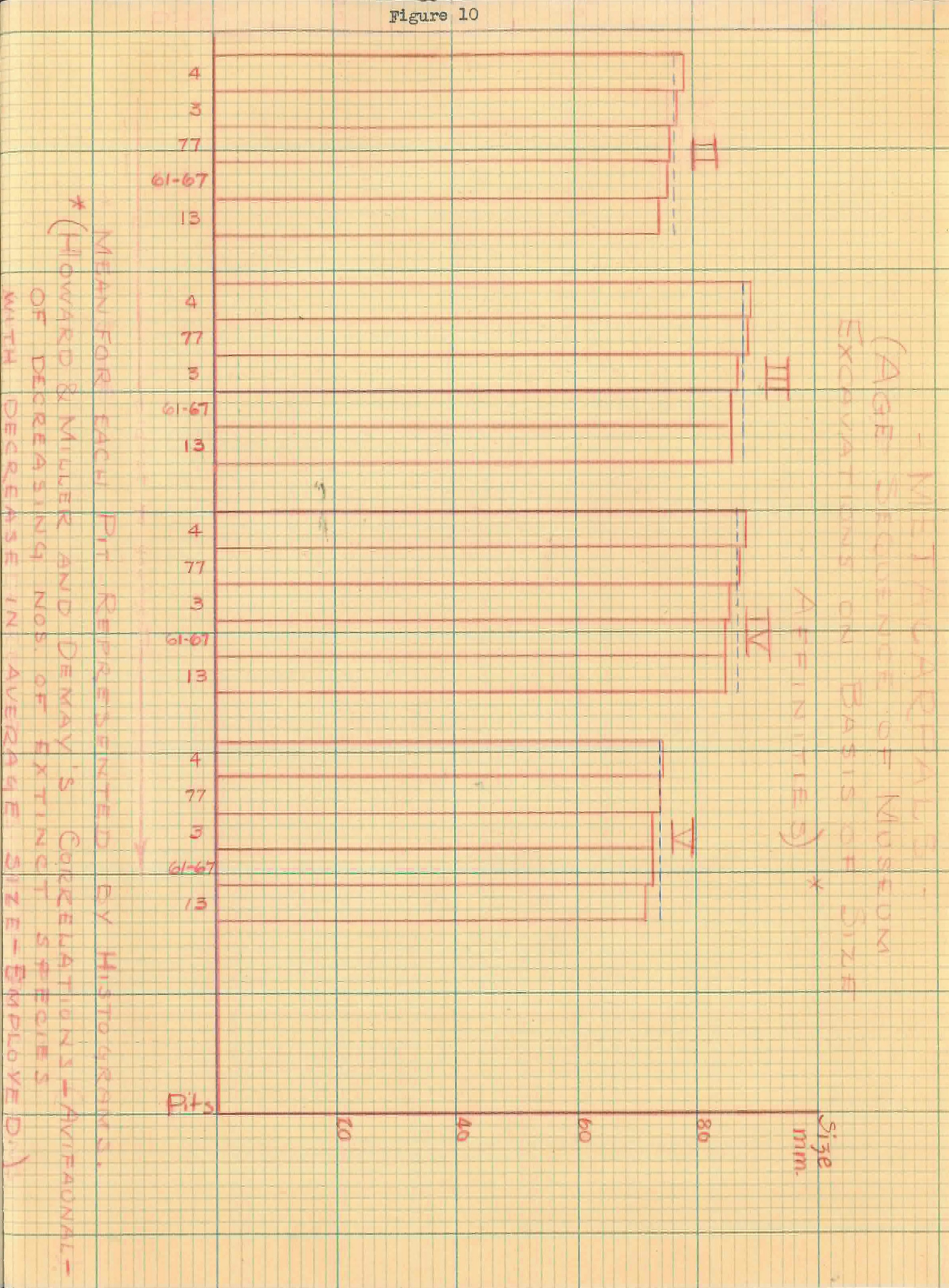
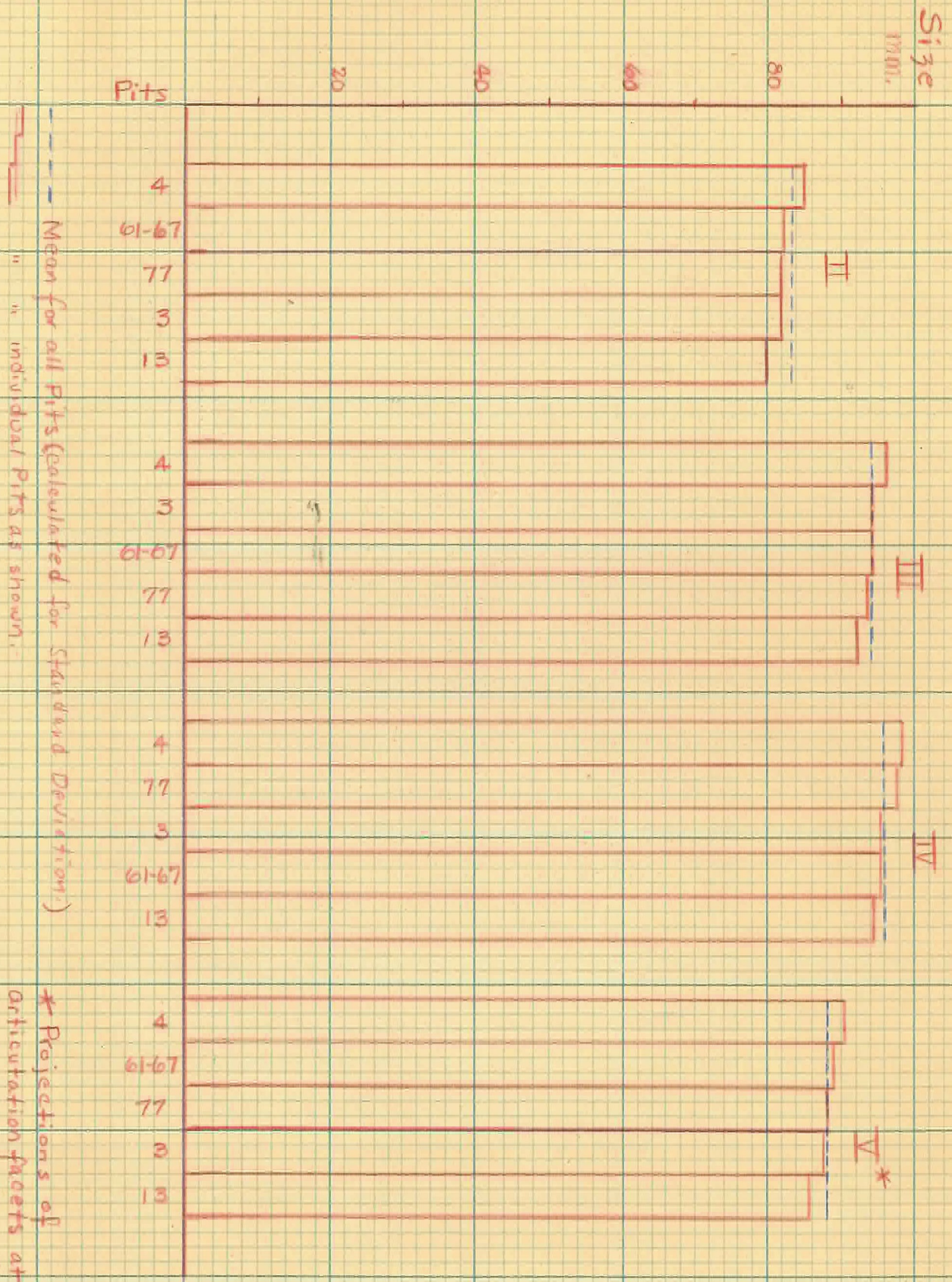

4
3
77
61-67
13
I
4
77
3
61-67
13
II
4
77
3
61-67
13
V
4
77
3
61-67
13
IV
Pits
20
40
60
80
Size mm.
(AGE - MULTIPLE CRITERIA)
EXCAVATIONS ON BAMILOUTH MOUND
ATTENUATED)
MEAN FOR EACH PIT REPRESENTED BY HISTOGRAMS.
* (HOWARD & MILLER AND DEMAY'S CORRELATIONS - AVIFAUNAL -
OF DECREASING NOS. OF EXTINCT SPECIES
WITH DECREASE IN AVERAGE SIZE EMPLOYED.)

Figure 11


Size
mm.
20
40
60
80
Pits
4
61-67
77
3
13
II
4
3
61-67
77
13
III
4
77
3
61-67
13
IV
4
61-67
77
3
13
V*
Means for all Pits (calculated for Standard Deviation)
" " individual Pits as shown.
* Projections of articulation facets at proximal end showed appreciable wearing.
METACARPALS I